Glycemic Control and Type 1 Diabetes Mellitus: Current Standard Treatment vs. Closed-Loop Insulin Pumps

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Glycemic Control and Type 1 Diabetes Mellitus: Current Standard Treatment vs. Closed-Loop Insulin Pumps
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Abstract

- As of 2019, 9.4% of the US population had a diagnosis of Diabetes Mellitus (DM). Although most of the data we studied encompassed type 1 (T1) and type 2 (T2) DM data in all ages of patients, the focus of this project will be on T1DM.
- There are effective methods currently available for the management of T1DM patients. These methods include: closed-loop insulin pumps that integrate a continuous glucose monitor (CGM) and insulin pumps into one effective system that calculates the needed insulin doses through complicated algorithms, CGM with self-blood glucose monitoring calibrations (SBGM) and insulin administrations, and SBGM with insulin administration.
- Literature reveals that closed-loop insulin pumps have the potential to provide better glycemic control for patients diagnosed with type 1 diabetes mellitus. These pumps are recommended for patients who are motivated to use them as directed and find them a desirable option.
- When patients can effectively manage their blood glucose, and practice healthy lifestyle and dietary choices, they can avoid unnecessary hospitalizations and long-term diabetic complications. This will simultaneously reduce healthcare-related costs, increase longevity and can improve the patient's quality of life.

Introduction

- According to the CDC, DM affects 30.3 million people in the US. Five percent of those cases are estimated to be Type 1 Diabetes Mellitus (T1DM), and the incidence of DM is steadily increasing with an estimated 1.5 million new cases of diabetes diagnosed in 2019 alone.  

DIABETES MELLITUS type 1


Statement of the Problem

- Current medical treatment for diabetic patients require self-blood glucose monitoring, this monitoring is done using self-blood glucose monitors (SBGM), which results in many finger sticks.
- Insulin injections can be performed by the patient or by an insulin pump that must be manually programed, which requires the patient to be proficient calculating insulin doses independently. There is a high potential for error related to insulin administration due to incorrect calculation of the glomerular or basic human error.
- When patients practice good blood glucose management they can avoid unnecessary hospitalizations and other diabetic complications, which will simultaneously reduce healthcare-related costs. These choices should be based on scientific evidence of effectiveness, not unreliable reports and should be made after considering the patient’s lifestyle and its’ impact on each method's particular benefits and challenges.
- The CDC (2017) states that in 2019, a total of 3.3 million hospital discharges and 14,000,000 emergency department visits were reported with diabetes being listed as any kind of diagnosis among 18 to 29-year-olds. The overall direct and indirect economic expenditures for diabetes in the US in 2013 was $245 billion; with an average of $76,700/person/year being medical expenditures related to diabetes. This is an estimated 2.3 times higher healthcare expenditures for people without diabetes. It is also important to note that DM was the seventh leading cause of death in the US in 2015.

Research Questions

- Will closed-loop insulin pumps provide better efficacy by monitoring glycemic control according to patient's blood glucose levels and glycosylated hemoglobin levels (HgbA1C) and decrease the incidence of hypoglycemic episodes, as compared to the current standard treatment of insulin pump therapy in patients with T1DM?
- What are the unique benefits of the different effective T1DM management methods?
- What are the challenges of these management methods and how will they affect their actual use-effectiveness?

Literature Review

- The DCT performed by Nathan, D. M., Bayless, M., Olender, P., Culley, S., Gubitosi-Klug, R., Lachin, J. M., Zimmerman, B. (2019) showed an improvement in the INT group with the following outcomes: HgbA1C: by three to six months to a level of 6.0 from the initial 8.1. Microvascular - results found were consistent, significant, and clinically meaningful. Cardiovascular - the patient population was generally too young and healthy to experience major CVD events (p=0.005). INT group with three events in three subjects vs. CON group with seven events in seven subjects. Beta cell preservation - INT group showed the rate of loss of C-peptide responsiveness by 50%.
- Diaries (2017) reports results from a randomized crossover trial comparing day-and-night closed-loop insulin delivery with usual pump therapy (four weeks each) in 29 adults with self- controlled T1DM (HgbA1C: 8.6%). A closed-loop system was used, in which the patient determined the amount of insulin administered before each meal. Participants had sensor glucose concentration in target range (3.9-10 mmol/L) 69.4% of the time during usual pump therapy, and 90.7% (1.54) of the time during closed-loop delivery which showed that the closed-loop system increased the proportion of time when glucose concentration was in target range by 3.3 percentage points (90.7% ± 0.5% vs. 69.4% ± 0.5%). Compared with usual pump therapy, closed-loop delivery reduced mean glucose concentration by 0.4 mmol/L (0.8 ± 0.18 vs. 1.0 ± 0.2), the proportion of time with glucose concentration above 10 mmol/L by 0.5 percentage points (4.5 ± 0.3 vs. 5.0 ± 0.3) and below 5 mmol/L by 0.51 (2.1 ± 1.3 vs. 0.5 ± 0.7), and glycemic dispersion (SD of glucose concentration) by 0.5 mmol/L (3.9 ± 0.7, p<0.001).

Common Risk Factors for Diabetic Complications

<table>
<thead>
<tr>
<th>Year</th>
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<td>2011-2014</td>
<td>Exercising</td>
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<tr>
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<tr>
<td>2011-2014</td>
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</tbody>
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Discussion

- Historical studies show that an intensive insulin regimen along with strict monitoring of blood glucose and HgbA1C levels provide patients with less long-term microvascular side effects of retinopathy, neuropathy, and nephropathy, as well as the macrovascular side effects of cardiac, peripheral vascular, and cerebrovascular disease.
- The DCT performed by Nathan, et al. (2019) demonstrated a drop of nearly –0.27% in HgbA1C and a slowed rate of loss in C-peptide responsiveness in Beta cell preservation. The DCT performed by Nathan, et al. (2019) demonstrated the need for earlier intervention in T1DM by showing that it can reduce severe renal impairment by 50%, risk of primary CVD outcomes by 42%, and nontarifal MI or stroke by 38%.

Applicability to Clinical Practice

- Initial management of a T1DM patient should include basic diabetes education, demonstration of SMBG technique, how to recognize and treat a hypoglycemic episode, and how to measure either blood or urine ketones in the emergency department. The T1DM patient’s endocrinology team should ideally include an endocrinologist, a certified nurse educator, dietitian, and possibly a mental health professional to provide support if the need arises.
- As potential future family practice providers, we must consider our patient’s lifestyle, education, and socioeconomic status to adequately make a choice for their T1DM management regimen.
- SBGM and insulin injections are relatively inexpensive, whereas newer technology is initially more expensive, but provide better efficacy and ease of use and also decrease in hypoglycemic events and hospitalizations. Clinicians must be mindful of what type of insulin delivery system that they are recommending for each patient.

- Closed-loop systems have proven themselves effective; and can lessen disease burden on the patient’s lifestyle. They are appropriate to prescribe for use in patients that can manage them efficiently and are motivated to do so. Closed-loop systems should be strongly considered as a long-term management method in patients with T1DM.

References


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